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The Commonwealth of Massachusetts

Department of Labor and Industries

DIVISION OF OCCUPATIONAL HYGIENE

OCCUPATIONAL HEALTH HAZARDS IN MASSACHUSETTS INDUSTRIES

II. PAINT AND VARNISH MANUFACTURE

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FOREWORD

The survey described in the following report is one of a series of industrial health studies conducted by the Division of Occupational Hygiene of the Massachusetts Department of Labor and Industries, in co-operation with the Works Progress Administration, as part of the Industrial Chemical Survey Project, W. P. A. No. 65-14-6060. This survey was supervised by Hervey B. Elkins, chemist of the division. The purpose of this work is to secure, as a basis for constructive preventive effort, knowledge of the extent and manner of use of the more important potentially hazardous chemicals in the industries of the Commonwealth. The wholehearted assistance of the establishments visited is gratefully acknowledged.

THE SERVICES OF THE DIVISION OF OCCUPATIONAL HYGIENE ARE AVAILABLE ON REQUEST IN CONNECTION WITH MATTERS PERTAINING TO THE HEALTH OF INDUSTRIAL AND MERCANTILE WORKERS.

OCCUPATIONAL HEALTH HAZARDS IN MASSACHUSETTS INDUSTRIES

II. PAINT AND VARNISH MANUFACTURE

Introduction

Eight paint manufacturing establishments employing a total of 389 wage-earners were included in the survey described in this report. The data obtained included the approximate quantities of toxic materials used, the precautions taken to prevent injury to health, and in seven plants determinations of the concentration of toxic dust present in the air in various departments.

No consideration is given to accident, fire, and electrical hazards in this report.

General Nature of Establishments

The plants visited were all relatively small, none employing over 100 wage-earners, the average number being 49. They were located in brick or wooden buildings of from one to five stories. Ample floor space was available in nearly all cases.

All 8 of the firms carried compensation insurance; 6 retained physicians on a part time basis; 1 had a nurse; 1 had pre-employment and periodic physical examinations for its employees; 4 had a safety engineer or a safety committee.

Environmental Factors

Methods of Ventilation:

All the rooms surveyed afforded natural ventilation through numerous windows and outside doors. Of the rooms known to contain a dust hazard, none were equipped with any type of mechanical ventilation.

Sweeping:

In spite of the fact that foremen of the mixing rooms stated that they were swept periodically by wet methods, the floors and objects in these rooms were found to be covered with considerable amounts of dust.

Eating Facilities:

In all the plants surveyed space for eating lunches was provided separate from the workroom; but usually it was located either in the washroom or locker room. During favorable weather many ate their lunches outdoors.

Cloakroom Facilities:

In all the plants surveyed adequate provisions were made for the caring of workers' street clothes. In spite of this fact, many would leave their sweaters or hats within areas where lead dust concentrations were found to be very high.

Washing Facilities:

Adequate provisions were made for washing hands and face but provisions for a shower for those workers who were exposed to considerable amounts of lead compounds were not available.

Hazardous Substances Used

The greatest health hazard in this industry is, of course, lead. This was present in several different pigments used in large quantities in all the 8 plants visited, but in 1 plant all pigments were bought in the form of oil pastes so that the chief source of dust, the handling of the dry pigment, was eliminated.

Benzol was used in making paint removers in 4 of the 8 plants.

Other toxic pigments used included cadmium, arsenic, selenium and chromium compounds. Among the less toxic pigments used in large quantities were lithopone, zinc oxide and titanium dioxide. Silica in various forms was used as a filler.

Toxic solvents used, more or less generally, included methanol, methyl acetone, toluol, solvent naphtha, carbon tetrachloride and ethylene dichloride. Less harmful were turpentine, acetone and various petroleum fractions.

Experience with Hazardous Materials

Only 1 establishment admitted a history of lead poisoning, having had 1 case in the past five years. In another plant irritation of the eyes due to some of the petroleum fractions used was reported as the only unfavorable experience with the chemicals used.

USE OF RESPIRATORS

All of the 7 plants using dry pigments furnished respirators to the men, but only 1 establishment used respirators approved by the Bureau of Mines for lead dust. Those provided in the other plants were in most cases designed for non-toxic nuisance dusts, and were not even of the type approved for siliceous dusts. In 6 of the 7 plants the use of respirators was said to be compulsory when mixing white lead.

MANUFACTURING OPERATIONS

Mixing Room:

The mixing operation in all the plants surveyed is carried out on either the floor above the grinding room or on a platform or mezzanine floor constructed over the paint grinding machine. The mixer pours a known quantity of vehicle (linseed oil and drier) into mixers from 5-gallon tins. These tins are filled from a tap connected to the linseed oil tank which is placed either outdoors or on a lower floor. The men open barrels or moisture proof paper bags containing the pigment and in the case of the paper bags the contents are dumped into the mixer. In the case of white lead, chrome green and chrome yellow (which are shipped in wooden barrels), the container is placed on a scale and a known quantity is either scooped or shoveled into the mixer. After the necessary time has elapsed to obtain the proper mixture, the mechanically mixed ingredients are allowed to run (by gravity) into the mill where the pigment is ground.

The mixing process ordinarily requires from fifteen minutes to half an hour. Unless there is an extraordinary run on lead paint, no individual engages in mixing more than two or three batches of lead paint in a single day, and on numerous days will mix no paint containing lead.

Grinding Room:

Due to the fact that in all plants the paint flows from the mixers into the mill by gravity the grinding room is in all cases directly below the mixing apparatus. The rate of flow is dependent upon the type and quality of the paint being prepared. The purpose of this grinding operation is to obtain a uniform mixture of pigment and vehicle. From the mill the uniformly mixed paint is allowed to drip into tanks of 100 to 200 gallon capacity. These tanks are equipped with rollers. As the batch is completed, the tanks are rolled away from the grinding apparatus. One half-hour before the paint is canned a propeller type agitator is inserted into this tank and the ground paint is stirred. Operators in the grinding room do not wear respirators.

Canning Department:

After the stirring of the paint the agitator is removed and the tank is rolled over to a canning department where it is hoisted by means of a chain pulley onto a table and from a tap in the tank the paint is run into cans of from 1-pint to 5-gallon capacity. These cans are then passed on to a labeling table where women are usually employed. Following the labeling operation the cans are placed in cartons and are sent along to the shipping room or stock room.

CLASSIFICATION OF WORKERS AS TO RACE, AGE AND LENGTH OF EMPLOYMENT

Women were found only in departments with little exposure to lead dust and are omitted from further consideration in this study.

Race:

A very large proportion (approximately 80%) of the workers in these plants were either foreign born or of foreign extraction. In none of the plants surveyed was a colored person employed in either the mixing or grinding department.

Age:

In the mixing department where a high exposure to lead dust was found the age limit varied. Ninety per cent of the mixers ranged in age from thirty-five to fifty years of age, the other 10% from twenty-five to thirty-five years of age. In departments with low exposure (grinding, canning, and labeling) there was a predominance of young persons.

Length of Employment:

In the mixing department the length of employment varied from two months to fifteen years. Approximately 95% of these mixers were found to be employed from three to fifteen years in the paint industry. In the grinding, canning and labeling departments of low exposure the length of service varied from one year to twenty years.

LEAD COMPOUNDS USED IN PAINT INDUSTRY

White lead (either the carbonate or sulfate) is the basic pigment for most outside house paints. It is mixed with cheaper pigments in varying degree depending on the quality of the paint. Chrome green and chrome yellow contain lead in the form of chromate. Other lead pigments include red lead and zinc lead white. Zinc oxide often contains a significant amount of lead. Typical analyses of these pigments are as follows (1):

Basic lead carbonate:	Lead carbonate	75%
	Lead hydroxide	25%
Sublimed lead sulfate:	Lead sulfate	80%
	Lead monoxide	15%
	Zinc oxide	5%
Zinc lead white:	Lead sulfate	50%
	Zinc oxide	50%
Zinc oxide:	Lead sulfate	5%
	Zinc oxide	95%
Red lead:	Lead monoxide	70%
	Lead dioxide	30%
Chrome yellow:	Lead chromate	85%
	Lead monoxide	15%
Chrome green:	Chrome yellow	80%
	Prussian blue	20%

TOXICITY OF DIFFERENT LEAD COMPOUNDS

When ingested, especially in single large doses, the toxicity of a metallic compound is to some degree dependent on its solubility, as the insoluble residue is eliminated quite rapidly through the intestines. For this reason insoluble lead compounds, such as the chromate and sulfide, are often considered to be non-toxic in comparison with the more soluble oxide, carbonate, etc.

The most careful work has shown, however, that when taken in small doses over a long period of time, especially by inhalation, the absorption of lead from insoluble compounds is nearly complete (2), (3), (4). The dust of lead chromate and lead sulfate must be guarded against as carefully as that of the carbonate. In fact, some authorities hold that lead chromate is the most injurious of the common lead compounds (3). The greater prevalence of poisoning from white lead may be ascribed to its far greater use.[1]

Inhaled lead has been shown to be much more effective in producing lead poisoning than ingested lead, even though the latter is in a soluble form (3).

DETERMINATION OF EXPOSURE TO LEAD DUST

A total of 47 samples of workroom air were taken with the Greenburg-Smith impinger apparatus. The volume of air samples varied from 0.4 to 1.8 cubic meters. The amount of lead present was determined by a modification of the method described by Fairhall (3), the solution being concentrated and the lead directly precipitated by means of potassium dichromate from a weakly acid solution. The precipitate was washed and then dissolved in hydrochloric acid, and titrated against stadardized sodium thiosulfate after the addition of potassium iodide. Blanks and control samples were run regularly, giving consistent results in all cases.

Mixing Room:

The survey revealed the mixing machines as the place of origin of atmospheric dust.

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[1] The present trend away from the use of white lead in interior paints is greatly reducing the lead hazard among painters. On the other hand while lead paints are seldom applied with a spray-gun, lacquers and enamels which are often sprayed may contain chrome green or chrome yellow which present a relatively new form of lead hazard in the painting industry.

In none of the plants surveyed were there exhaust or fan systems near the mixing machines. The lead compounds when dumped or shoveled into the mixers gave off clouds of dust which were disseminated throughout the room. Due to its small particle size this dust was slow in settling, for analysis showed very high concentrations to be present one-half hour after the mixing process had been completed. This dust would deposit on floors, sills and various objects in the room or diffuse to other departments. The faces of the men engaged in mixing were often covered with dust. The tests being performed in warm weather, drafts from open windows and doors were numerous. The drafts would again disseminate the settled dust around the room and in this manner a hazardous concentration of dust was at all times present in the mixing room. Three samples obtained previous to mixing (last mixture made the preceding day) showed high concentrations of lead to be present in the air.

It was also observed that sweeping during working hours was customary.

Caution at all times was not taken in opening containers of lead compounds and in moving these containers (usually open barrels), the operators were often negligent. This rough treatment resulted in the production of an unnecessarily large amount of dust.

In the case of chrome green (containing lead chromate) it was observed that the dust of this pigment was conspicuous on all objects within a radius of 20 feet of the mixer where this paint was being mixed.

Table I gives the results of the analyses of the 40 samples picked up in the mixing departments of the 7 plants using dry pigments.

Grinding Room:

It was found that the grinding process did not give rise to any lead dusts. In 2 plants where the grinding machines were in the same room as the mixing machines low concentrations of lead were found in the vicinity of these grinding machines. This dust present was due to the dusts generating from the mixing department. Table II gives the results of the 4 samples obtained in this department.

Canning and Labeling Rooms:

In the canning and labeling rooms it was apparent that these operations did not give rise to any lead hazard and that the paint was carefully handled in canning and at no time was ever allowed to dry or be scraped when dried. In the 2 plants where the canning and labeling departments were in the same room as the mixing department very low concentrations were found. Again this was due to dust generated in the mixing department.

Dust Containing Arsenic

One test was made by a mixer making a paint containing Paris green. The sample was tested for arsenic and copper and both were found to be present in a concentration of 150 mg./10 cubic meters of air. The operator wore a respirator throughout the process.

Toxic Concentration of Lead Dust

Legge and Goadby in 1912 suggested 5 mg. per 10 cubic meters as the maximum permissible concentration for lead dust (2). The volume of 10 cubic meters may be taken as representative of the amount of air inhaled in a working day. Russell and his colleagues after a thorough study of lead poisoning in a storage battery plant established 1.5 mg. as being safe provided the exposure was not too greatly prolonged (5). When exposure is only occasional a proportionately higher concentration can be safely endured.

Discussion of Results

A striking feature of the results shown in Table I is the great difference in concentrations of lead dust, especially close to the mixing operation, in the different plants. Even when the two lowest values are thrown out as being unrepresentative there is a wide spread between 15.6 mg. and 132 mg., the extreme values obtained. This spread may be due to several factors: size of batch; composition of batch; care used in handling pigment; rate of air circulation in the vicinity of the mixing machine. A high concentration of lead dust does not indicate negligence on the part of the management, except in so

Table I.—Results of Air Analyses in Mixing Departments.

LOCATION	Type and Quality of Paint Prepared	Source of Lead	Number of Men Exposed	Number of Men Wearing Respirators	Operation	Duration of Test Avg.	CONCENTRATIONS (mg. Pb./10 cu. meters)		
							min.	max.	avg.
By mixer (7 samples)	Outside white	White lead (dry) zinc oxide	12	8	Preparing and completing mix.	(1) 31 min.[1] (2) 25 min.[2]	(1) 3.8[1] (2) 15.6[2]	132.0 132.0	58.0[1] 71.4[2]
10 ft. from mixer (7 samples)	Outside white	White lead (dry) zinc oxide	12	8	Preparing and completing mix.	25 min.	2.8	41.0	12.2
By mixer (6 samples)	Outside white	White lead (dry) zinc oxide	12	0	After mixing operation	27 min.	2.1	122.0	30.8
10 ft. from mixer (5 samples)	Outside white	White lead (dry) zinc oxide	11	0	After mixing operation	33 min.	1.3	20.6	6.65
By mixer (5 samples)	Chrome green	Lead chromate	12	7	Preparing and completing mix.	41 min.	2.3	15.8	9.4
10 ft. from mixer (4 samples)	Chrome green	Lead chromate	12	7	Preparing and completing mix.	25 min.	1.2	18.6	6.2
By mixer (2 samples)		Dust from previous mixes	4	0	Previous to mix.	40 min.	1.3	27.0	14.1
Center of room (5 samples)		Dust from floors, objects, and previous mixes	7	0	Lunch period	63 min.	1.2	2.5	1.8

Table II.—Results of Air Analyses in Grinding Rooms[3]

By grinders (2 samples)	Outside white	Dust emanating from mixing department	17	0	Grinding of paint	64 min.	1.2	1.7	1.4
20 ft. from grinders (2 samples)	Outside white	Dust emanating from mixing department	17	0	Grinding of paint	64 min.	1.2	2.5	1.8

Table III.—Results of Air Analyses in Canning and Labeling Departments[3]

Canning and Labeling Tables (3 samples)	Outside white and chrome green	Dust emanating from mixing department	19 M 5 F	0 0	Canning and labeling	60 min.	.30	1.2	.80

[1] Includes 2 samples taken over a period of one hour which include conditions **after** mixing as well as during the mixing process.
[2] Includes only the 8 samples taken during actual mixing operation.
[3] In the 2 plants where mixing, grinding, canning and labeling are done in same room.

far as it is due to unnecessarily careless handling of the lead compounds. Similarly a low lead concentration may be due to a fortuitous combination of circumstances rather than a praiseworthy enforcement of precautionary measures. A partial exception may be made in one plant where a dough mixer was used; in this case, although a large quantity of paint was mixed in a single batch, the lead dust concentration was low (19 mg.). Exceptional care was used in the handling of the material in this case.

In mixing chrome green paint the lead concentration was less than with white lead, but still substantial (with one exception).

The concentration of lead in the air before and after the mixing operation, also that in the center of the mixing room when no lead paint was being mixed, was high enough to be significant, in no case being below one milligram per ten cubic meters. Exposure to such concentrations was long continued and complete, since respirators were not worn. Similarly the concentrations of lead in the grinding department (Table II) in those plants where they were not well separated from the mixing rooms, were close to the 1.5 mg. per ten cubic meters which is believed to be the lowest concentration which will cause lead poisoning. On the other hand there seemed to be little lead hazard in the canning and labeling departments (Table III). This was fortunate since women were employed in these departments.

Use of Respirators

As shown in Table I, the majority of the men wore respirators when working in high lead dust concentrations. In two plants they were not worn when mixing chrome green paint; in only one they were not used for mixing white lead. Fortunately, the mixing operation is sufficiently short and intermittent to make the use of respirators practicable. In only one plant, however, was a respirator of the type approved for lead dust by the U. S. Bureau of Mines furnished. The degree of protection furnished by the nuisance type respirator used in the other plants is uncertain. Substitution of one of the approved types, which are but slightly more expensive, is a highly desirable move.

Table IV.—Lead Exposure of Paint Mixers

Operation	Conc. Pb. Mg./10 Cu. Meters			Length of Exposure	Lead Inhaled		
	Min.	Avg.	Max.		Min.	Avg.	Max.
(1) Mixing white lead	15.6	71.4	132	25 min.	0.8 mg.	3.8 mg.	6.8 mg.
(2) After mixing	1.7	18.8	71	30 min.	0.1 mg.	1.2 mg.	4.4 mg.
(3) Mixing chrome green	2.3	9.4	15.8	25 min.	0.1 mg.	.5 mg.	.8 mg.
(4) Miscellaneous	1.2	1.6	2.5	6 hrs., 40 min.	1.0 mg.	1.3 mg.	2.1 mg.
				Total............	2.0 mg.	6.8 mg.	14.1 mg.
				Subtracting (1) & (3)............	1.1 mg.	2.5 mg.	6.5 mg.

Table IV shows the possible lead exposures of a workman in the mixing departments of paint factories when lead paints are being mixed. It is assumed that he mixes one batch of white lead and one batch of chrome green paint during the day[1], and that he breathes uniformly at a rate of ten cubic meters of air per eight hours[2].

The total amount of lead inhaled if no respirators are worn is shown in the first series of totals. Under the most favorable conditions encountered (minimum concentration) the amount is above the threshold value of 1.5 mg., while under the worst conditions enough is taken in to constitute a bad hazard. Fortunately, probably no one is exposed to these last conditions for any extended period. The average exposure without a respirator is great enough to constitute a real hazard

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[1] The total consumption of white lead by the seven plants surveyed was estimated at 630 tons annually; that of chrome green and chrome yellow combined at 165 tons a year. Assuming an average batch of white lead to contain 500 lbs. of lead pigment, and the average weight of colored lead pigments to be 200 lbs. per batch, the average plant would mix white lead 360 times a year, and chrome green or chrome yellow 235 times a year; or a total of about two batches a day, if production were uniform throughout the year.

[2] This value is higher than that often taken. According to Henderson & Haggard's "Noxious Gases", the average amount of air inhaled in 8 hours would be 6.7 cubic meters for a man walking 2 miles per hour; 12.5 cubic meters for a man walking 4 miles per hour. A value midway between these is taken as representing a reasonable rate of exertion for manual labor of this type.

If a perfect respirator is worn during the actual mixing operations, so that no lead is inhaled, the exposure under the most favorable conditions is low enough to be considered non-hazardous. The average exposure is well above the 1.5 mg. threshold, however, while under the worst conditions it is above the conservative 5 mg. threshold. Actually there is undoubtedly some leakage through even the best respirators, so that these exposures should be taken as somewhat lower than those actually occurring.

On the other hand there are many days when no lead paint is mixed. On such days the lead exposure should be negligible if the room has been thoroughly cleaned since lead was last used. It is probable, however, that such conditions do not always exist.

The survey was made in the spring and early summer during mild weather, when windows and doors were for the most part open, and conditions favorable for natural ventilation. Inasmuch as the demand for house paint is largely seasonal and its peak is in the summer, these conditions are typical of those existing when the bulk of the lead paints is being made.

INCIDENCE OF LEAD POISONING

While complete statistics are not available, Table V gives some idea of the incidence of lead poisoning in the paint industry.

Table V

	Paint Manufacturing	All Industries
Lead poisoning cases investigated by Massachusetts Department of Labor and Industries. (1929-34)	3	212
Number wage earners in Massachusetts. (1934)	661	421,300
Average number of cases per 1,000 wage earners in Massachusetts. (1929-34)	0.75	0.08
Deaths from lead poisoning in United States. (1925-27)	7	398
Reported cases lead poisoning per 1,000 employees in England. (1911-14)	15	
Lead poisoning cases in England. (1919-34)	171	4,215
Fatal cases in England (1919-34)	8	425

These statistics show lead poisoning to be much more prevalent in the paint manufacturing industry than in industry as a whole. The ratio in Massachusetts is not striking, however, when the amount of lead handled by this industry, in proportion to other industries, is considered. Lead poisoning in this industry seems more prevalent in England, but it is probable that the English figures include the manufacture of white lead and other pigments as well as the mixing of paints.

RECOMMENDATIONS

Although it has been repeatedly demonstrated that most industrial lead poisoning is caused by inhalation of dust containing lead, the belief still persists in the paint industry that the chief danger lies in swallowing lead. While the following recommendations include measures designed to prevent the accidental ingestion of lead compounds, it should be borne in mind that the real hazard is the dust in the workroom atmosphere, and the most important precautions are the ones which protect the workman from breathing air containing large amounts of lead:

1. *Respirators:*

The use of respirators approved by the U. S. Bureau of Mines for lead dust should be required in all mixing operations involving the use of appreciable quantities of lead pigments. When not in use, these respirators should be kept in a clean place and should be inspected periodically by a plant official.

2. *Cleaning of rooms:*

The mixing room should be cleaned at night, preferably every day. A vacuum cleaner system is desirable, but if not available wet sweeping should be used. The men doing this work should wear respirators.

3. *Isolation of lead mixers:*

In so far as possible, the mixers used for lead pigments should be isolated from the rest of the mixing room, preferably being located in a separate small room. The air flow should be from the main room into the lead room. This effect could be secured by window fans in the latter room.

4. *Care in handling lead:*

The employees should be instructed to be as careful as possible in handling dry lead compounds, in order to avoid the production of unnecessary quantities of dust.

5. *Personal habits:*

Employees should be required to take full advantage of cloakroom and washroom facilities. Lunches should not be allowed in the workroom. The men exposed to lead should be encouraged to drink milk, which is a preventive measure of recognized value.

6. *Medical supervision:*

Medical examination of employees on employment and periodically thereafter is a desirable feature.

Early diagnosis of lead poisoning is important. First manifestation of symptoms should be followed by immediate physical examination. Lead poisoning can be prevented through detection by blood examination before first symptoms appear.

7. *Employment of non-susceptible persons:*

In so far as possible, persons especially susceptible to lead poisoning should not be employed in the mixing department. Women, young persons and negroes are on the average more susceptible than mature white males. Persons with tubercular tendencies, anemic persons, nephritics, sclerotics, neurotics and alcoholics should not be exposed to lead.

SUMMARY

The chemical health hazards in the paint manufacturing industry were studied in eight establishments, and the most important one was found to be lead.

The lead exposure of workers in the departments chiefly affected was determined in seven of the plants. It was found that when lead paint is being mixed the average amount breathed by workers in the mixing department is about two and a half milligrams of lead per day. This is one milligram greater than the permissible value of one and a half milligrams.

The precautions taken in this industry were described and critically discussed. Conditions on the average would seem conducive to occasional mild cases of lead poisoning; and when the customary precautions are omitted more severe cases would seem possible.

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